DOCUMENT RESUME

ED 223 692 TM 820 837

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TITLE	Matching Factors Derived from the Same Set of Items but Different Groups of Respondents: A Review of Methods with an Example.
SPONS AGENCY	New York State Education Dept., Albany.
PUB DATE	Mar 82
NOTE	38p.; Paper presented at the Annual Meeting of the American Educational Research Association (66th, New York, NY, March 19-23, 1982); Attachments A and B have been omitted because of publisher's ownership of copyright; Attachments C and D contain small print; For a related document, see TM 820 838.
PUB TYPE	Speeches/Conference Papers (150) -- Reports - Research/Technical (143)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	*Attitude Measures; *Comparative Analysis; Evaluation Methods; *Factor Analysis; Group Testing; Item Analysis; Response Style (Tests); Secondary Education; Student Development; Test Construction; Test Items; Vocational Education
IDENTIFIERS	*Congruence Coefficient (Burt); Factor Matching; *Salience Index (Cattell)

ABSTRACT

Procedures devised for computing factor matching statistics in questionnaire construction are described. In a study of the impact of vocational education on social, affective and nontechnical development of students, an attitude questionnaire to measure outcomes was developed. Each item in the final section had a six-point Likert type response scale ranging from "strongly agree" to "strongly disagree." Using a factor analysis of data from occupational and nonoccupational students' responses, the high-loading items on each factor formed a scale score. Factor analysis brought up the question of whether factor loading patterns for respondent groups were congruent. To evaluate the congruence, Burt's congruence coefficient (the sum of cross-products of the loadings being compared divided by the square root of the cross-product of the sum of the squared loadings) was compared with Cattell's salient variable similarity index (classifying all variables loading on a factor as salient or nonsalient). Application of the methods in comparing and matching factors derived for the two respondent groups on the same variables showed the congruence coefficient to be easier to compute and interpret and a conservative test. The salient index was practical with relatively few variables and factors. (CM)

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ED223692

MATCHING FACTORS DERIVED FROM THE SAME SET OF ITEMS BUT DIFFERENT GROUPS OF RESPONDENTS: A REVIEW OF METHODS WITH AN EXAMPLE

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Presented at the
Annual Meeting
of the
American Educational Research Association

March 19-23, 1982
New York, New York

The author would like to acknowledge and thank Dr. James A. Dunn, Institute Director; Dr. Clinton Walker, Outcomes Project Director; and his many fellow staff members of the Institute for Occupational Education at Cornell University for their ideas, guidance, and assistance in carrying out this study. Naturally, any errors are the responsibility of the author.

The work reported here was part of a project funded by the New York State Education Department. The opinions here do not necessarily reflect the position or policy of NYSED and no official endorsement by that office should be inferred.

MATCHING FACTORS DERIVED FROM THE SAME SET OF ITEMS BUT DIFFERENT GROUPS OF RESPONDENTS: A REVIEW OF METHODS WITH AN EXAMPLE

Objectives of this study

This study sought to (1) review the literature on matching factors derived from factor analyses of the same set of items but different groups of respondents, (2) devise practical procedures for researchers to use in computing and interpreting such statistics, and (3) demonstrate the usefulness of factor matching in questionnaire construction.

Background

Factor matching here means determining the congruence of one pattern of factor loadings with that of another pattern of factor loadings, the two sets of loadings being derived from the same variables but two distinct groups of subjects. It is assumed here that the matching begins after the unique factor resolution by one means or another has taken place in each group of subjects.

The question "Are the factor loading patterns for Group A on this instrument congruent with those for Group B on the same instrument?" does not appear to have been asked very often in questionnaire construction, although as Cattell (1978) notes, a number of ability and personality studies have dealt with it. This is odd since it would certainly seem to be wise in many studies to supplement a factor analysis of a total group with an additional examination to determine whether the pattern of factor loadings for one sub-group of interest is congruent with that of another sub-group of interest (e.g., experimental vs. control subject, boys vs. girls, etc.). Perhaps one reason

it has not been asked more often is the lack of much practical advice on how to accomplish factor matching in a way that will help the real-world researcher. While factor matching has been the topic of a number of papers over the past forty years, only a few treat the subject as other than an exercise in theoretical statistics. From a practical aspect, to be useful, a factor matching technique requires both a readily usable mathematical formula for computing the matching statistics and a method for interpreting the results, such as a table of significances.

This problem became particularly apparent while the writer was working on a research study of the social outcomes of occupational education among high school students. It is known that occupational education has a number of impacts on students, foremost among them economic returns and the development of technical skills. This study, however, hypothesized that vocational programs also have a positive impact on the social, affective, and non-technical development of students. It is a lengthy study, now in its third year, and it is sponsored by the Association of Vocational Education Administrators in New York, and funded by the New York State Education Department. Work on the project is being conducted by staff of the Institute for Occupational Education at Cornell University.

One task of the study was to develop an attitude questionnaire to measure such non-technical outcomes as self-confidence, ability to handle stress, social skills, and other possible outcomes. The plan for the study called for the final developed instrument to be administered to both occupational and non-occupational students at the end of their sophomore year and to the same group two years later at the end of their senior year. (The study involved only New York State students. Typically, in that state, occupational students

enter a program of occupational studies in their junior year, attending half-day sessions at an occupational school for technical training, the other half-day being spent in academic studies at their home high school.) In this way, occupational students could be compared to non-occupational students at two points in time. Changes in attitudes among occupational students over the two years it takes to complete their studies could also be assessed.

The prototype questionnaire had four sections: (1) attitude towards school items, (2) work values items, (3) demographic items (e.g., sex, age, program, etc.), and (3) a pool of 97 attitude items, written by project staff or derived from other sources. This paper will deal only with the fourth section. Each item in that section had a six-point Likert type response scale, ranging from "strongly agree" to "strongly disagree."

The plan called for the prototype to be administered to occupational and non-occupational students, and for the resulting data from the 97 items to be factor analyzed, the highest loading items on each factor to be retained and used in a scale building procedure to produce considerably shorter, more reliable scales. This procedure is based on the recommendations of McKennell (1977). Responses on the high loading items on each factor are added together to form a scale score. Items which do not have a high correlation with the scale score or which do make a positive contribution to the statistical reliability of the scale are dropped.

However, the factor analysis brought up the question of whether the factor loading patterns for the occupational and non-occupational students were congruent. If they were not, it might mean that the instrument was measuring two different things for the two groups. In response to this problem, this writer conducted a search through the literature to find a procedure for matching factors based on the same set of items for two

different groups of respondents. Eventually, two solutions were located which could be applied to the survey data.

The remainder of this paper is concerned primarily with a discussion of these two methods, and the presentation of results which were produced when these methods were applied to the project data. However, since readers of this paper may wish to delve further into the issue of factor matching, it seems only fair to mention some of the more prominent articles which he or she will encounter along the way, articles which did not contribute to a practical solution, although they did often contribute to an understanding of the issues.

Review of the literature

One of the first suggestions was that Kaiser's index of factor similarity might be useful (Kaiser, Hunka, and Bianchini, 1971). The article's abstract describes the index: "A method for relating factors between studies is developed. This approach yields a measure of relationship between all factors under consideration - a measure which may be interpreted as a correlation coefficient." In the example in the article, the authors derive an index of 0.85 and conclude that the pairing of six variables was reasonable. Unfortunately, this method seems to compare one matrix of factors with another, yielding a single coefficient, which cannot be interpreted since there are no significance tables for it (unless one assumes from the statement in the abstract that a table for the significance of correlation coefficients can be used). This index was judged not to be a practical alternative because it is computationally complex and because the immediate problem in the study was to match a factor from one group of respondents with a factor from another group of respondents, rather than matching the two factor matrices.

Other articles were cited frequently in the factor matching literature.

One popular citation was an article by Tucker (1951) which is actually a mimeographed Army report and now apparently unobtainable anywhere. However, it would appear that the content of it is mostly repeated in Tucker's later article (1958). This lengthy and highly technical article was later criticized by Gibson (1960). Another popular citation is Wrigley and Neuhaus (1955) which is only a brief abstract of a conference paper. Pinneau and Newhouse (1964) propose a coefficient of factor similarity, but give no practical examples for computing such a coefficient or interpreting it.

The solution was finally discovered in Cattell's book The Scientific Use of Factor Analysis in Behavioral and Life Sciences (1978). In this book, he summarized a number of articles dealing with factor matching (Burt, 1941; Schneewind and Cattell, 1970; Cattell, Balcar, Horn, and Nesselroade, 1969; and others). Cattell presents two practical, fairly easy to use, methods for comparing and matching factors derived from analyses of data from two groups of respondents (but on the same variables). These two methods, Burt's congruence coefficient and Cattell's salient index, are discussed in the next sections.

Burt's congruence coefficient

The first method is the congruence coefficient and was originally proposed by Burt (1941) although a number of the sources reviewed above also mention it. The formula for computing it is the sum of the cross-products of the loadings being compared, divided by the square root of the cross-product of the sum of the squared loadings. Cattell gives this as

$$r_c = \Sigma b_{j_1} b_{j_2} \Big/ (\Sigma b^2_{j_1} \; \Sigma b^2_{j_2})^{\frac{1}{2}}$$

where b_{j_1} and b_{j_2} are the loadings of variable a_j on the compared factors F_1 and F_2

As Cattell notes, the practical problem with this is that "statisticians have not given us a clear test of its significance...." Schneewind and Cattell (1970) attempted to remedy this by generating distributions of congruence coefficients from typical loading patterns over many actual psychological experiments by Monte Carlo procedures. They note that the coefficient values tend to vary with the number of variables and number of factors, although the variation is not great. Their significance table for the congruence coefficient is given in Attachment A to this paper.

Cattell's salient index

The second method proposed by Cattell is his salient variable similarity index. It differs from the congruence coefficient by proceeding nonparametrically. It classifies all variables by loadings on a given factor as salient or nonsalient. The salient loadings are classified as positive or negative. Nonsalient loadings fall within what is called the hyperplane, the area within which loadings are considered to be not significantly different from zero. It is Cattell's position that a factor either loads on a variable or it does not. The "presence of low but significant loadings not far from the true hyperplane, is simply an appearance due to several other factors happening to operate simultaneously on the same variable," reducing its loading on that particular one. Cattell suggests different ranges for defining the hyperplane, but considers + or - 0.10 to be the "shrewdest" choice. Positive salient variables have factor loadings at or above + 0.10. Negative salient variables have factor loadings at or below - 0.10. Variables between - 0.10 and + 0.10 are considered to fall in the hyperplane. Thus, each

loading for each factor can be classified into one of three categories. The table in Figure 1 shows how this classification can be cross-tabulated for two factors being compared and gives the formula for computing the salient index.

He warns, however, of some complicatedness and uncertainty of interpretation in this formula unless certain conditions are met. First, the same number of variables should lie in the hyperplane of each of the factors being compared. It may be necessary to adjust the hyperplane for one or both of the two factors being compared to achieve this. Second, the number of positively loaded and negatively loaded salients should be equalized in a factor by reflecting the sign of the original set of variables until this is achieved. In practice, however, in the analysis of the project data, this proved difficult to do.

Significance values for the salient index are given in Attachment B to this paper.

Using the methods

With these two methods in hand, it was now possible to apply them to the data from Part D of the study questionnaire. The prototype questionnaire was administered to a random sample of 380 occupational students and 430 non-occupational students in New York. Both sophomores and seniors were included in each group. The 97 items were factor analyzed for the total group of respondents , using the SPSS FACTOR subprogram. This was a principal factor analysis with a varimax rotation. Cattell's scree test and a subjective examination of the results suggested that no more than 14 factors could reasonably be interpreted. Items not loading higher than .35 on any of these 14 factors were dropped from further analysis. The remaining 55 items were factor analyzed separately for the occupational and non-occupational sub-groups. The scree test suggested that no more than 10 factors could be retained for each group. Both the congruence coefficient and the salient

	Factor 2			
Factor 1	Positive Salients	Hyperplane	Negative Salients	
Positive Salients	f_{11}	f_{12}	f_{13}	n_1
Hyperplane	f_{21}	f_{22}	f_{23}	n_2
Negative salients	f_{31}	f_{32}	f_{33}	n_3
	$n_{.1}$	$n_{.2}$	$n_{.3}$	n

NOTE: The f's indicate joint frequency, with the same n variables in both factors.

Cattell gives the formula for the salient index as follows:

$$s = \frac{f_{11} + f_{33} - f_{13} - f_{31}}{f_{11} + f_{33} + f_{13} + f_{31} + \frac{1}{2}(f_{12} + f_{21} + f_{23} + f_{32})}$$

FIGURE 1

TABLE AND FORMULA FOR CATTELL'S
SALIENT VARIABLE SIMILARITY INDEX

index were to be computed to compare these factor loadings. The complete set of factor loadings on the 55 items for both the occupational and non-occupational groups are given as Tables 1 and 2, respectively.

The occupational and non-occupational student sub-groups will be referred to hereafter as Groups J and K, respectively. The occupational student factors are labelled as J1 to J10 and the non-occupational student factors as K1 to K10.

Factor loadings for each variable (item) were punched onto machine-readable cards and an SPSS system file was established. Each item had 21 variables: its number, ten occupational student factor loadings named J1 to J10, and ten non-occupational student factor loadings named K1 to K10. Using this SPSS system file made it possible to use some of the data transformation facilities of SPSS to compute some of the intermediate statistics needed for both the congruence coefficients and the salient indexes.

Attachment C shows part of the printout for computing the sum of squared loadings for all the factors, and the sum of the cross-products of the loadings for all the factors. The SPSS DO REPEAT facility was used for all these computations and the CONDESCRIPTIVE subprogram was used to obtain the sums of these. Because of the length of this printout, only the control cards and the first few pages of results are reproduced here, as Attachment C. With these results, it was a simple procedure with a hand calculator to compute the 100 congruence coefficients. The resulting coefficients are presented in Table 3.

The salient index proved to be more difficult because of Cattell's warning about the need to adjust the hyperplane window for each variable for each match and to adjust the positive and negative salients. With 55 variables and 100 matches to be made, it was judged to be too time-consuming and laborious to do this adjustment. Instead, the SPSS RECODE facility was used to

recode all the loadings into three categories. Loadings at or above + 0.10 were positive salients, loadings at or below - 0.10 were negative salients, and loadings between - 0.10 and + 0.10 were in the hyperplane. The SPSS CROSSTABS subprogram was used to compute and display the 100 cross-tabulations. It was then a simple matter to use a hand calculator to compute the salient index for each comparison. Sample pages from the printout are presented as Attachment D. The resulting indexes are presented in Table 4.

The results

For 55 variables, a congruence coefficient of about + or - 0.52 is needed to achieve significance at the .001 level. The results in Table 3 were remarkably similar to the subjective judgments of the project staff regarding the similarity of the of the factors, and the items composing them. J1 matches K1, J2 matches K6 and K9, J3 matches K2, and so on. There is a particularly interesting similarity among factors J4, J5, K7, and K10. Neither J9 nor J10 match much of anything. These results also demonstrate that, even with a statistical tool such as the congruence coefficient, it is still difficult ot make completely unambiguous matches between factors from different groups.

Results for the salient index are considerably less easy to interpret than the congruence coefficients. It appears that these results were probably affected by the adjustments Cattell warned about and which were not made.

A comparison of the results for the congruence coefficient and the salient index is also interesting. There are a total of 33 salient indexes significant at the .001 level and 13 congruence coefficients significant at the .001 level. Twelve of the 100 comparisons are significant at the .001 level in both tables; 21 are significant only for the salient index, and just one is significant only for the congruence coefficient.

Based on these results, it would appear that the congruence coefficient is easier to compute and interpret and is a more conservative test for comparing factors derived from factor analyses of the same group of items for two different groups of persons. The salient index appears to be practical only for situations with relatively few variables and factors, because of the extensive work needed to make the adjustments in the size of the hyperplane "window" and in the distribution of the positive and negative salients.

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TABLE 1

OCCUPATIONAL STUDENT
FACTOR LOADINGS (J1 TO J10)

(see next page)

Item	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6	FACTOR 7	FACTOR 8	FACTOR 9	FACTOR 10
D1	0.45421	0.15613	0.01801	0.21783	-0.14844	0.11622	-0.02578	-0.00949	-0.02750	-0.25441
D2	0.51167	0.06974	-0.02745	0.20952	-0.04353	-0.08999	0.03636	0.07400	-0.06253	-0.23241
D4	-0.00923	0.10829	0.08849	0.12828	-0.03440	-0.08509	0.66029	0.03615	-0.00116	-0.04412
D5	0.16252	0.24968	0.17793	0.04246	0.12977	0.02378	0.62582	-0.00475	-0.05331	0.16801
D7	0.18450	-0.01450	0.01712	0.58264	-0.00439	0.01450	0.15682	-0.06108	-0.09438	-0.01743
D8	0.56245	0.07928	-0.03611	0.21573	-0.03822	-0.10120	0.13018	-0.04024	0.10366	0.11080
D11	0.07496	0.07187	0.61743	0.08072	-0.01532	-0.07005	0.19958	0.01511	0.00765	0.01393
D12	0.17273	0.47548	-0.03670	0.16488	-0.07023	-0.09058	0.15569	0.03017	0.10578	0.18932
D14	0.04322	-0.02302	-0.07821	-0.05399	0.05115	-0.05646	-0.00308	-0.64752	0.04327	0.03955
D16	-0.22952	0.11766	-0.07311	-0.09263	0.23585	0.11082	-0.00395	-0.12248	0.13894	0.03641
D17	0.13951	0.52296	-0.01295	0.17388	-0.04099	-0.04842	0.03132	0.00126	-0.02102	0.08950
D18	0.06906	0.02254	-0.58471	0.02935	0.16217	0.19827	0.03081	-0.08446	0.03781	0.03505
D19	0.18418	0.63937	0.05824	0.10715	0.00036	-0.07644	0.06370	-0.02572	-0.05912	0.06686
D21	0.22178	0.08421	-0.03123	0.55501	0.00078	-0.05760	-0.08547	0.02260	-0.01848	-0.01682
D25	0.09688	0.05197	0.62317	0.14855	-0.04825	-0.07659	0.12060	0.04676	0.00493	0.14893
D26	0.51039	0.53169	0.05220	-0.10277	0.12308	-0.21602	0.21507	0.05201	0.06018	-0.13642
D27	-0.15225	0.04694	-0.07777	-0.08299	0.03407	0.52729	-0.03355	-0.01834	-0.04501	0.09744
D29	0.45111	0.13616	0.01878	0.27547	0.03595	-0.14157	0.07927	0.05231	0.10603	0.11816
D35	0.12292	0.07967	0.06146	0.54500	-0.07489	0.01504	0.01648	0.15412	0.00914	-0.01046
D36	0.59726	0.17652	0.07824	0.11195	-0.10632	-0.01091	0.13918	-0.05707	-0.04489	0.14163
D41	-0.01107	-0.05477	-0.11815	0.08726	0.03441	0.56755	-0.11649	0.05182	0.00080	0.09385
D42	0.13102	0.04351	0.15625	0.55305	0.03091	-0.01177	-0.01751	0.05922	0.09160	0.09048
D43	0.53607	0.10309	0.03575	0.18048	0.17862	-0.19250	0.01587	0.04861	-0.05087	0.00950
D44	-0.14123	-0.00116	-0.04530	-0.07366	0.21955	0.26300	0.01491	0.10010	-0.03690	-0.02435
D46	0.28407	0.08505	0.05123	0.08939	0.01341	0.01914	0.00961	0.43676	0.27594	0.24594
D47	0.19839	0.35301	0.21293	0.12020	0.15009	-0.15895	0.15896	0.18151	0.10962	0.24083
D51	-0.09930	-0.10039	-0.00629	-0.01969	0.14282	0.47001	0.03082	-0.03133	0.09114	-0.13356
D52	-0.10208	-0.14357	-0.11404	-0.06617	0.15956	0.48846	-0.07213	0.09292	-0.00154	-0.13324
D53	0.32854	0.18341	0.14093	0.08790	-0.07005	0.05102	0.03472	0.13404	0.36724	0.04452
D54	-0.02564	-0.25071	-0.10674	0.04611	0.08803	0.23203	-0.26562	0.09855	-0.14913	0.03903
D55	0.50576	0.20656	0.01801	0.07446	-0.01932	-0.09005	0.12459	0.03701	0.18270	0.05796
D56	0.20339	0.06294	0.11749	0.14008	-0.10360	0.04142	-0.04201	0.38888	0.30298	0.04635
D57	0.39087	0.12862	0.09116	0.06562	-0.06049	-0.00445	-0.02318	0.06423	0.47849	0.03159
D58	0.32681	0.07910	0.13213	0.14836	-0.00204	-0.05692	0.06975	0.08876	0.14147	0.05172
D60	0.26925	0.06528	0.57223	0.13344	-0.00461	0.02172	-0.02862	0.11090	0.24267	-0.01251
D61	0.17333	0.55607	0.07019	0.09343	-0.05966	0.13743	0.04290	0.03663	0.10681	-0.15563
D62	-0.29456	-0.11970	-0.14043	0.04210	0.20508	0.29082	0.04366	0.03786	0.15396	0.02935
D64	0.45413	0.15290	0.07521	0.11666	-0.04748	-0.03988	-0.07272	0.05564	0.10087	-0.04807
D68	0.06993	0.27104	0.02484	-0.00064	-0.12133	-0.07731	0.31143	0.01160	0.29466	-0.07496
D69	-0.29802	-0.16763	-0.11968	-0.04065	0.15407	0.27850	0.24253	-0.08438	0.29999	0.13433
D70	0.23831	0.17378	0.04443	0.46456	-0.00170	-0.07953	0.11675	0.05738	0.19503	-0.06890
D71	-0.48916	0.01530	0.00309	-0.03875	0.18876	0.06774	-0.00347	0.04812	0.02877	0.19324
D73	-0.01006	-0.05325	-0.03984	0.06913	0.37650	0.00048	-0.00892	-0.06985	-0.08527	0.04343
D74	0.03716	-0.08165	-0.40797	0.00467	0.13754	0.18847	-0.05389	-0.20570	0.02964	0.21197
D75	0.08282	-0.19443	-0.13538	0.03230	0.42614	0.26213	-0.13499	-0.06258	-0.06617	0.13462
D78	-0.09726	0.12680	0.03983	-0.04424	0.41783	0.13887	0.05871	-0.11709	0.24669	-0.02478
D79	-0.09208	0.02750	0.03939	-0.07609	0.57954	0.16580	0.04747	-0.00364	-0.13966	-0.07232
D82	-0.12450	-0.21370	-0.12294	0.07840	0.30725	0.18203	-0.31807	0.02839	-0.07550	0.16788
D85	0.60023	0.09335	-0.01115	0.05383	-0.18265	-0.17764	0.01837	0.08667	0.11915	0.10351
D88	0.21614	0.53182	0.12334	-0.14194	0.05309	-0.18769	0.15319	0.03361	0.10598	-0.23379
D91	-0.02302	-0.03978	-0.16971	-0.01717	0.33796	-0.01387	-0.00298	-0.04469	0.30609	-0.16329
D92	0.02111	0.02221	-0.14913	-0.06274	0.17261	-0.04409	-0.01096	-0.66482	0.00655	0.03457
D93	0.53599	0.10971	0.07320	0.04712	-0.00921	-0.01500	-0.04071	-0.07440	-0.00761	0.02010
D95	0.35727	0.28077	0.30690	0.04412	0.02161	-0.00888	-0.03565	0.09443	0.05662	-0.01070
D97	-0.05864	0.00037	-0.39080	-0.04690	0.46326	0.08894	-0.06306	-0.07189	-0.01398	0.09200

TABLE 2

NON-OCCUPATIONAL STUDENT
FACTOR LOADINGS (K1 TO K10)

(see next page)

Item	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6	FACTOR 7	FACTOR 8	FACTOR 9	FACTOR 10
D1	0.23808	0.13990	0.10509	0.12364	0.04380	0.09097	-0.07750	0.62418	0.08025	-0.07943
D2	0.32391	0.22154	0.16557	-0.07954	0.19107	0.07071	-0.02408	0.60045	0.14868	-0.00829
D4	-0.00756	0.25280	0.02945	0.07336	0.73994	0.20438	-0.05372	0.02587	0.06879	-0.03490
D5	0.03645	0.13343	-0.03403	0.04199	0.69775	0.18756	-0.02567	0.03369	0.10896	0.05918
D7	-0.04758	-0.04365	0.62843	0.01740	-0.01940	0.02090	-0.05064	0.09689	0.05899	-0.11997
D8	0.57760	0.01228	0.06323	0.07896	-0.01311	0.12638	-0.00885	0.14859	0.16399	-0.16116
D11	0.16550	0.71716	0.12822	0.13048	0.13798	0.19891	-0.05777	-0.09737	0.07282	0.05834
D12	0.04293	0.12028	0.03044	-0.08325	0.09102	0.74620	-0.12238	0.00619	0.24334	0.04191
D14	-0.01553	-0.08846	-0.28132	-0.63699	-0.11925	0.02004	-0.08204	0.00565	-0.07837	0.02141
D16	-0.18956	0.02231	-0.17987	-0.12580	0.12735	-0.00020	0.02891	-0.25936	0.15064	0.34819
D17	0.07512	0.08009	0.10744	-0.02044	-0.00731	0.26387	-0.10927	0.05533	0.41315	-0.04777
D18	0.06103	-0.50600	-0.12939	-0.28794	-0.02764	-0.07391	0.14837	-0.15752	-0.10832	0.01471
D19	0.09444	0.06449	0.02700	-0.02043	0.24006	0.54958	-0.02036	0.06016	0.28296	0.08898
D21	0.13124	-0.06001	0.66343	0.02059	-0.01208	0.10201	0.06918	0.03014	0.12194	-0.03329
D29	-0.03077	0.62967	0.02040	0.15699	0.37518	0.12746	0.05683	0.04002	0.12502	-0.11656
D26	0.16122	0.08522	0.13403	0.09471	0.22075	0.23742	-0.00514	0.16441	0.65381	-0.00750
D27	-0.19088	-0.07839	-0.00858	0.18037	-0.17681	0.08391	0.50474	-0.08451	-0.17870	0.17246
D29	0.39780	0.17796	0.19333	0.07748	-0.02498	0.19904	-0.14392	0.28996	-0.01779	0.07618
D39	0.12777	0.11903	0.81295	0.02834	0.00433	-0.07418	-0.08916	0.11439	0.04328	-0.05224
D36	0.58211	0.10729	0.10072	0.09061	-0.02248	0.05734	-0.11441	0.26837	0.07438	0.03827
D41	0.07706	0.02296	-0.11000	0.18688	-0.13478	0.06184	0.57632	-0.00120	-0.14640	0.06044
D42	0.21674	0.04639	0.48488	0.23888	0.00529	0.07279	-0.02805	-0.01953	-0.09097	0.05096
D43	0.54095	-0.04296	0.04541	0.14659	0.20627	0.07280	0.23122	-0.09984	-0.02458	-0.12931
D44	-0.20071	-0.06623	-0.13263	-0.03890	-0.04020	0.02494	0.05764	-0.05503	0.04796	0.48384
D46	0.14116	0.25092	0.11225	0.58607	0.00224	0.11086	0.19466	0.10937	-0.07448	-0.04523
D47	0.15512	0.19577	0.10334	0.11712	0.14847	0.63445	0.03370	0.06225	0.01061	-0.09585
D51	-0.09497	0.06795	-0.01612	0.02411	-0.11504	0.08285	0.03330	0.01729	-0.10092	0.53507
D52	-0.03064	0.09183	0.08633	-0.04704	0.06577	0.00909	0.22415	-0.05622	-0.05189	0.29438
D53	0.21481	0.26013	0.10991	0.36930	0.19102	0.24053	-0.03592	-0.00027	-0.11075	-0.09314
D54	0.04487	-0.01573	0.01272	-0.11319	-0.45179	-0.33029	0.20181	0.05973	-0.19135	-0.00561
D59	0.46288	0.18776	0.12261	-0.05980	0.20506	0.11064	-0.07481	0.04572	0.10032	-0.19066
D56	0.11408	0.15588	0.18773	0.51749	0.02484	0.08993	-0.02992	0.26448	-0.04546	-0.09184
D57	0.50544	0.16705	-0.04118	0.10839	0.02819	0.17098	-0.14125	0.09726	-0.11729	-0.14760
D58	0.30243	0.27680	0.13354	0.09284	0.21331	0.01185	0.10246	0.19400	-0.21182	-0.25729
D60	0.18546	0.77928	0.02251	0.20589	0.14099	0.13775	-0.01295	0.04856	-0.01506	0.02105
D61	0.30240	0.16775	-0.04919	-0.04784	0.23635	0.38968	0.02824	0.16732	0.24233	0.00794
D62	-0.32710	-0.00856	0.01950	-0.11491	0.16636	-0.15150	0.31154	0.03003	-0.18071	0.41613
D64	0.51412	0.17052	0.19913	-0.07349	0.03862	0.00911	-0.02978	0.13543	0.01979	-0.12370
D68	0.11294	0.19386	0.14833	0.18244	0.37318	0.48743	-0.10909	0.03583	0.02318	0.06913
D69	-0.27253	0.10038	-0.12395	0.05128	0.09021	0.04728	0.20790	-0.29177	-0.12609	0.08045
D70	0.18724	0.15015	0.59866	0.11233	0.01092	0.08898	-0.04476	0.13277	0.06524	0.04641
D71	-0.11558	0.10805	-0.06321	-0.09401	-0.03613	-0.00633	0.10507	-0.42691	-0.08596	0.05606
D73	-0.05201	0.00624	0.01525	-0.18487	0.01046	-0.29552	0.53169	-0.05313	0.05409	0.01016
D74	0.01154	-0.25743	-0.02098	-0.33227	-0.10647	0.01246	0.34782	-0.02020	-0.20966	0.05167
D75	-0.02261	-0.35831	0.19802	-0.16983	-0.28499	-0.12102	0.21660	-0.01560	-0.05382	0.18440
D78	-0.14934	0.01393	-0.20238	-0.01935	0.05140	-0.07011	0.38558	-0.12488	0.25360	0.03901
D79	-0.11384	-0.07904	0.00860	0.03419	-0.09045	-0.04306	0.38245	-0.07516	0.06678	0.07990
D82	-0.13664	-0.22309	0.06478	-0.22143	-0.45152	-0.01065	0.20222	-0.12689	-0.07498	0.15941
D85	0.66642	-0.05268	0.16245	0.06533	-0.01945	0.04719	-0.09723	0.06939	0.10171	0.02239
D88	0.20001	0.06681	0.10231	0.08482	0.22105	0.20204	0.04121	0.15806	0.62216	-0.09200
D91	-0.05271	-0.01211	-0.03967	-0.18212	0.14407	-0.12646	0.25378	-0.24980	0.09890	0.26696
D92	-0.03075	-0.13525	-0.00682	-0.76036	-0.07899	0.06336	0.07434	-0.01774	-0.07578	0.04858
D93	0.48824	-0.09341	0.01681	0.01855	-0.03736	-0.03150	-0.06946	0.08425	0.03427	-0.09453
D95	0.28722	0.21778	0.29860	0.18259	0.03208	0.02887	0.00012	0.26408	0.07431	-0.00064
D97	0.01716	-0.30843	0.07066	-0.13660	-0.12403	-0.11606	0.24166	-0.04756	-0.03552	0.30938

TABLE 3

CONGRUENCE COEFFICIENTS
FOR COMPARISON OF FACTORS FROM
OCCUPATIONAL AND NON-OCCUPATIONAL STUDENT GROUPS

Non-Occ Student Factors	Occ Student Factors									
	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10
K1	94*	49	26	43	-25	-35	15	23	33	05
K2	35	38	87*	29	-28	-23	40	39	42	00
K3	47	26	23	88*	-09	-16	10	26	13	00
K4	29	21	51	23	-32	-05	19	84*	34	03
K5	27	54*	42	14	-12	-32	85*	16	32	-12
K6	41	79*	33	27	-18	-21	50	16	38	19
K7	-22	-19	-31	-10	71*	65*	-18	-04	01	19
K8	70*	38	24	40	-39	-22	10	23	05	-29
K9	32	75*	25	09	02	-41	37	05	04	-31
K10	-40	-17	-30	-18	55*	61*	-07	-09	02	-03

NOTES:

1. Leading decimal points have been omitted.

2. An asterisk (*) indicates a congruence coefficient significant at the .001 level or beyond.

TABLE 4

SALIENT VARIABLE SIMILARITY INDEXES
FOR COMPARISON OF FACTORS FROM
OCCUPATIONAL AND NON-OCCUPATIONAL STUDENT GROUPS

Non-Occ Student Factors	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10
K1	86*	52*	41*	44*	32	43*	34	29	43*	07
K2	52*	52*	52*	52*	21	11	52*	37	54*	11
K3	70*	37	38	45*	25	39	37	28	33	04
K4	39	38	63*	31	41*	23	29	45*	23	00
K5	36	52*	47*	23	04	31	55*	20	46*	16
K6	53*	61*	49*	33	11	28	58*	21	44*	17
K7	28	40	42*	08	65*	49*	27	05	00	04
K8	63*	34	35	36	37	30	24	29	22	14
K9	34	67*	28	14	08	36	36	10	16	00
K10	46*	33	39	29	36	32	32	00	09	15

NOTES:

1. Leading decimal points omitted.

2. An asterisk (*) indicates a salient index significant at the .001 level or beyond.

ATTACHMENT A

TABLE FOR SIGNIFICANCE OF CONGRUENCE COEFFICIENTS
IN FACTOR MATCHING

ATTACHMENT B

TABLE FOR SIGNIFICANCE OF
SALIENT VARIABLE SIMILARITY INDEX

Note: Both these tables were reproduced from copyrighted material in the original paper. They have been omitted here. The interested reader may find these tables in R. B. Cattell, The Scientific Uses of Factor Analysis in Behavioral and Life Sciences, New York: Plenum Press, 1978, pp. 568-571.

ATTACHMENT C

USING SPSS TO COMPUTE
BURT'S CONGRUENCE COEFFICIENT

This attachment shows sample pages from a computer printout. SPSS data transformation commands were used to compute cross-products of the factor loadings and to square the loadings. The SPSS subprogram CONDESCRIPTIVE was then used to get the sums of these computed variables. The final page of the attachment shows the computation using these sums to get the congruence coefficient for the first occupational student factor (J1) and the first non-occupational student factor (K1).

```
*********SPSS     FT06F001 ***********RM3,PR2 ***FMT <00>* ****SAF1 LINES ***  9:00.54AM  24 MAR 81  WARREN2   816 BOWERS AVEASURVY
SPSS BATCH SYSTEM                                                              03/24/81        PAGE    1

SPSS FOR OS/360, VERSION H, RELEASE 8.1, MAY 20, 1980

                              CURRENT DOCUMENTATION FOR THE SPSS BATCH SYSTEM
ORDER FROM MCGRAW-HILL:  SPSS, 2ND ED. (PRINCIPAL TEXT)        ORDER FROM SPSS INC.:  SPSS STATISTICAL ALGORITHMS
                         SPSS PRIMER (BRIEF INTRO TO SPSS)                         SPSS POCKET GUIDE, RELEASE 8
                         SPSS UPDATE (USE W/SPSS,2ND FOR REL. 7 & 8)               KEYWORDS: THE SPSS INC. NEWSLETTER


DEFAULT SPACE ALLOCATION..      ALLOWS FOR..   128 TRANSFORMATIONS
WORKSPACE     89600 BYTES                      512 RECODE VALUES + LAG VARIABLES
TRANSPACE     12800 BYTES                     2048 IF/COMPUTE OPERATIONS

          1 PAGESIZE        9999
          2 RUN NAME         AVEA OUTCOMES SURVEY - FACTOR MATCHING TECHNIQUES
          3 VARIABLE LIST   ITEM,J1 TO J10,K1 TO K10
          4 INPUT MEDIUM    CARD
          5 N OF CASES      55
          6 INPUT FORMAT    FIXED(X,F2.0,10F7.5/3X,10F7.5)

          ACCORDING TO YOUR INPUT FORMAT, VARIABLES ARE TO BE READ AS FOLLOWS

          VARIABLE   FORMAT  RECORD    COLUMNS

          ITEM       F 2. 0      1     2-  3
          J1         F 7. 5      1     4- 10
          J2         F 7. 5      1    11- 17
          J3         F 7. 5      1    18- 24
          J4         F 7. 5      1    25- 31
          J5         F 7. 5      1    32- 38
          J6         F 7. 5      1    39- 45
          J7         F 7. 5      1    46- 52
          J8         F 7. 5      1    53- 59
          J9         F 7. 5      1    60- 66
          J10        F 7. 5      1    67- 73
          K1         F 7. 5      2     4- 10
          K2         F 7. 5      2    11- 17
          K3         F 7. 5      2    18- 24
          K4         F 7. 5      2    25- 31
          K5         F 7. 5      2    32- 38
          K6         F 7. 5      2    39- 45
          K7         F 7. 5      2    46- 52
          K8         F 7. 5      2    53- 59
          K9         F 7. 5      2    60- 66
          K10        F 7. 5      2    67- 73

THE INPUT FORMAT PROVIDES FOR  21 VARIABLES.   21 WILL BE READ
IT PROVIDES FOR  2 RECORDS ("CARDS") PER CASE.  A MAXIMUM OF   73 "COLUMNS" ARE USED ON A RECORD.

          7 VAR LABELS      J1  OCCUPATIONAL FACTOR 1 /K1 NON-OCCUPATIONAL FACTOR 1 /
          8                 J2  OCCUPATIONAL FACTOR 2 /K2 NON-OCCUPATIONAL FACTOR 2 /
          9                 J3  OCCUPATIONAL FACTOR 3 /K3 NON-OCCUPATIONAL FACTOR 3 /
         10                 J4  OCCUPATIONAL FACTOR 4 /K4 NON-OCCUPATIONAL FACTOR 4 /
```

```
                11                  J5  OCCUPATIONAL FACTOR 5 /K5 NON-OCCUPATIONAL FACTOR 5 /
                12                  J6  OCCUPATIONAL FACTOR 6 /K6 NON-OCCUPATIONAL FACTOR 6 /
                13                  J7  OCCUPATIONAL FACTOR 7 /K7 NON-OCCUPATIONAL FACTOR 7 /
                14                  J8  OCCUPATIONAL FACTOR 8 /K8 NON-OCCUPATIONAL FACTOR 8 /
                15                  J9  OCCUPATIONAL FACTOR 9 /K9 NON-OCCUPATIONAL FACTOR 9 /
                16                  J10 OCCUPATIONAL FACTOR 10/K10 NON-OCCUPATIONAL FACTOR 10/
                17 VALUE LABELS     J1 TO K10 (1)NEGATIVE SALIENT (2)HYPERPLANE (3)POSITIVE SALIENT
                18 TASK NAME        COMPUTE STATISTICS NEEDED FOR BURT'S COEFFICIENT OF CONGRUENCE
                19 DO REPEAT        X = SQJ1 TO SQJ10/J = J1 TO J10
                20 COMPUTE          X= J**2
                21 END REPEAT


                22 DO REPEAT        Y = SQK1 TO SQK10/K = K1 TO K10
                23 COMPUTE          Y = K**2
                24 END REPEAT


                25 DO REPEAT        J1KX = J1K1 TO J1K10/K = K1 TO K10
                26 COMPUTE          J1KX = J1 * K
                27 END REPEAT


                28 DO REPEAT        J2KX = J2K1 TO J2K10/K = K1 TO K10
                29 COMPUTE          J2KX = J2 * K
                30 END REPEAT


                31 DO REPEAT        J3KX = J3K1 TO J3K10/K = K1 TO K10
                32 COMPUTE          J3KX = J3 * K
                33 END REPEAT


                34 DO REPEAT        J4KX = J4K1 TO J4K10/K = K1 TO K10
                35 COMPUTE          J4KX = J4 * K
                36 END REPEAT


                37 DO REPEAT        J5KX = J5K1 TO J5K10/K = K1 TO K10
                38 COMPUTE          J5KX = J5 * K
                39 END REPEAT


                40 DO REPEAT        J6KX = J6K1 TO J6K10/K = K1 TO K10
                41 COMPUTE          J6KX = J6 * K
                42 END REPEAT


                43 DO REPEAT        J7KX = J7K1 TO J7K10/K = K1 TO K10
```

```
46 DO REPEAT       J8KX = J8K1 TO J8K10/K = K1 TO K10
47 COMPUTE         J8KX = J8 * K
48 END REPEAT

49 DO REPEAT       J9KX = J9K1 TO J9K10/K = K1 TO K10
50 COMPUTE         J9KX = J9 * K
51 END REPEAT

52 DO REPEAT       J10KX = J10K1 TO J10K10/K = K1 TO K10
53 COMPUTE         J10KX = J10 * K
54 END REPEAT

55 CONDESCRIPTIVE SQJ1 TO SQJ10,SQK1 TO SQK10,J1K1 TO J10K10

***** GIVEN WORKSPACE ALLOWS FOR 1782 VARIABLES FOR CONDESCRIPTIVE PROBLEM *****

56 STATISTICS      12
57 READ INPUT DATA
```

VARIABLE SQJ1

SUM 4.531

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE SQJ2

SUM 2.694

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE SQJ3

SUM 2.262

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE SQJ4

SUM 2.108

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE SQJ5

SUM 1.916

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE SQJ6

SUM 1.915

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE SQJ7

SUM 1.515

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

SUM 1.509

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE SQJ9

SUM 1.265

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE SQJ10

SUM 0.778

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE SQK1

SUM 3.725

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE SQK2

SUM 2.957

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE SQK3

SUM 2.732

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE SQK4

SUM 2.566

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE SQK5

SUM 2.504

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE SQK6

SUM 2.501

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE SQK7

SUM 2.034

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE SQK8

SUM 1.801

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE SQK9

SUM 1.765

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE SQK10

SUM 1.489

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE J1K1

SUM 3.852

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE J1K2

SUM 1.273

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE J1K3

SUM 1.659

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

VARIABLE J1K4

SUM 0.979

VALID OBSERVATIONS - 55 MISSING OBSERVATIONS - 0

Sample computation: Computing Burt's congruence coefficient for the first occupational student factor (J1) and the first non-occupational student factor (K1).

The sum of the cross-products of the J1 and K1 factor loadings (from the sum for SPSS variable J1K1)..... 3.852

The sum of the squared J1 loadings (from the sum for SPSS variable SQJ1)..... 4.531

The sum of the squared K1 loadings (from the sum for SPSS variable SQK1)..... 3.725

Substituting in Burt's formula (given earlier in the paper), we get

$$\frac{3.852}{(4.531 \times 3.725)^{\frac{1}{2}}} = \frac{3.852}{(16.878)^{\frac{1}{2}}} =$$

$$\frac{3.852}{4.108} = 0.938$$

ATTACHMENT D

USING SPSS TO COMPUTE
CATTELL'S SALIENT VARIABLE SIMILARITY INDEX

This attachment shows sample pages from a computer printout. The SPSS RECODE facility was used to recode the factor loadings as positive and negative salients with variables between -0.10 and +0.10 being in the hyperplane. The SPSS subprogram CROSSTABS was then used to produce the tables needed to compute the index. The example shown compares factors J1 and K1. Notice that in this example the locations of the cells is different from that shown in Figure 1 in the text of this paper. In effect, the table in the example has been rotated 180 degrees so that the cell marked f_{11} in Figure 1 and which is in the upper left of the table in that figure, appears in the lower right in the printout example. The cell marked f_{33} which appears in the lower right in Figure 1 appears in the upper left in the printout example. Other cells have been changed accordingly. This does not affect the computations.

CPU TIME REQUIRED.. 0.19 SECONDS

```
62 TASK NAME      CATTELL'S SALIENT INDEX - HYPERPLANE = + OR - .10
63 *RECODE        J1 TO K10('LO' TO -0.10 = 1)(-0.09999 TO 0.09999 = 2)
64                (0.10 TO 'HI' = 3)
65 CROSSTABS      VARIABLES = J1 TO K10(1,3)/TABLES = J1 TO J10 BY K1 TO K10
66 STATISTICS     ALL
```

***** "CROSSTABS" PROBLEM REQUIRES 3600 BYTES WORKSPACE NOT INCLUDING VALUE LABELS *****

***** GIVEN WORKSPACE ALLOWS FOR 3583 LABELLED VALUES *****

CATTELL'S SALIENT INDEX - HYPERPLANE = + OR - .10
FILE NONAME (CREATION DATE = 03/24/81)

CROSSTABULATION OF J1 OCCUPATIONAL FACTOR 1 BY K1 NON-OCCUPATIONAL FACTOR 1

J1	K1	1 NEGATIVE SALIENT	2 HYPERPLANE	3 POSITIVE SALIENT	ROW TOTAL
1 NEGATIVE SALIENT	COUNT	7	1	0	8
	ROW PCT	87.5	12.5	0.0	14.5
	COL PCT	77.8	5.3	0.0	
	TOT PCT	12.7	1.8	0.0	
2 HYPERPLANE	COUNT	2	13	2	17
	ROW PCT	11.8	76.5	11.8	30.9
	COL PCT	22.2	68.4	7.4	
	TOT PCT	3.6	23.6	3.6	
3 POSITIVE SALIENT	COUNT	0	5	25	30
	ROW PCT	0.0	16.7	83.3	54.5
	COL PCT	0.0	26.3	92.6	
	TOT PCT	0.0	9.1	45.5	
COLUMN TOTAL		9 16.4	19 34.5	27 49.1	55 100.0

5 OUT OF 9 (55.6%) OF THE VALID CELLS HAVE EXPECTED CELL FREQUENCY LESS THAN 5.0.
MINIMUM EXPECTED CELL FREQUENCY = 1.309
RAW CHI SQUARE = 58.33717 WITH 4 DEGREES OF FREEDOM. SIGNIFICANCE = 0.0000
CRAMER'S V = 0.72824
CONTINGENCY COEFFICIENT = 0.71744
LAMBDA (ASYMMETRIC) = 0.60000 WITH J1 DEPENDENT. = 0.64286 WITH K1 DEPENDENT.
LAMBDA (SYMMETRIC) = 0.62264
UNCERTAINTY COEFFICIENT (ASYMMETRIC) = 0.50624 WITH J1 DEPENDENT. = 0.48688 WITH K1 DEPENDENT.
UNCERTAINTY COEFFICIENT (SYMMETRIC) = 0.49637
KENDALL'S TAU B = 0.78895 SIGNIFICANCE = 0.0000
KENDALL'S TAU C = 0.70909. SIGNIFICANCE = 0.0000
GAMMA = 0.96752
SOMERS'S D (ASYMMETRIC) = 0.77131 WITH J1 DEPENDENT. = 0.80700 WITH K1 DEPENDENT.
SOMERS'S D (SYMMETRIC) = 0.78875
ETA = 0.84064 WITH J1 DEPENDENT. = 0.83648 WITH K1 DEPENDENT.
PEARSON'S R = 0.83639 SIGNIFICANCE = 0.0000

ATTACHMENT D (Continued)

Sample computation: Computing Cattell's salient variable similarity index for the first occupational student factor (J1) and the first non-occupational student factor (K1).

From the preceding printout page, we can derive the following values:

$f_{11} = 25$ $\quad f_{12} = 5$

$f_{33} = 7$ $\quad f_{21} = 2$

$f_{13} = 0$ $\quad f_{23} = 2$

$f_{31} = 0$ $\quad f_{32} = 1$

Substituting in Cattell's formula (given earlier in the paper), we get

$$\frac{25 + 7 - 0 - 0}{25 + 7 + 0 + 0 + \frac{1}{2}(5 + 2 + 2 + 1)}$$

$$= \frac{32}{32 + 10/2} = \frac{32}{37} = 0.8649$$